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ADAPTATION IN DOUGLAS FIR

J. V. Hofmann

U. S. Forest Service, in charge Wind River Experiment Station, Washington

The limits of the distribution of plants, it is believed, are determined by their ability to adapt themselves to various conditions. What form the inherent characters take is not known, although the outward changes of form and cell structure are readily ascertained. In plant breeding many generations of the species concerned are required in order to develop forms that in some measure meet the conditions of the new environment. This kind of procedure is possible with plants that produce one or more generations annually. When, however, the modifications of a tree species are studied, the results may be obtained by experimental evidence only after several decades. A study of tendencies must of necessity be the basis used by foresters in determining the possible effects on future forests caused by qualities inherited from the present seed trees. In order to find the inherent tendencies in Douglas fir, *Pseudotsuga taxifolia,* a seed study was made that covered the range of the species from west central Oregon to northern Washington and from the Cascade Mountains to the Pacific coast.

Douglas fir is the predominant species as well as the predominant individual in the extensive forests of this region. It has proved itself to be a successful competitor with its associated species from sea level to the upper slopes on the mountains. Throughout this wide range of conditions the form of the tree changes from the giant of the valley, towering to a height of 225 feet, to the prostrate bush on the wind-swept mountain sides. It persists in the short growing seasons of the high altitudes and takes advantage of the long growing seasons of the lowlands. The forest, once established, remains throughout the life of that generation; but the crucial tests, which determine whether it will longer remain or not, lie in its ability to produce seed, in the vitality and quality of the seed, and in the possibilities for the establishment of the seedlings.

In the fall of 1912 seed was gathered from 127 trees representing 29 different conditions, each of which involved the influence on the parent tree of one or more of the factors of soil, age, elevation, locality, health, size, and density of the stand in which it grew. The data presented constitute the summarized results of six years' work, including six annual germination tests and the growing of one-year-old stock from each germination series. Each parent tree is represented by a test of 300 seeds in each series.

A very detailed record was taken, which gives the habitat and condition of each pistillate parent tree. The staminate parent tree remains an unknown quantity, however, because the flowers of the Douglas fir are monoecious and diclinous with the pistillate flowers among the tip buds of the branches and the staminate flowers farther back. The species is pollinated entirely by the wind, and this arrangement of flowers decreases the chance for self-pollination. Seeds from the same tree may, therefore, represent hybridization involving several of the factors described as influencing the parent tree. The general tendencies due to any one set of factors are brought out by the study. The influence of these inherent qualities is what the forester must consider in the gathering of seed for reforestation, in leaving seed trees when cutting, and in forest improvement by selection.

When one is gathering seed for reforestation it is important to know the quantity and quality of seed produced by trees under different conditions, in order that the best seed may be obtained. The results of this study show that the influence of the environment and condition of the parent tree are reflected in its progeny. It was found that the size of the cone depends directly upon the vigor of the cone-bearing shoot. Variations in the size of cones and in the vigor of the shoot on which the cones grew were consistent throughout, whether on the same tree or on different trees. For this reason the younger trees averaged the largest cones, and in turn, the largest cones contained the largest seeds. Trees 15 years old had an average of 3,500 seeds to the pound, and trees 600 years old had an average of 5,700 seeds to the pound.

Trees infected with fungi ("conks") produced as many cones as did sound trees, but apparently there had been a lower percentage of fertilization in the cones of the "conky" trees. The cones from the "conky" trees averaged 13,300 seeds to the bushel of cones as compared with 21,500 seeds to the bushel of cones from sound trees. Trees grown on poor, rocky, or gravel soil produced only 62 percent as much seed as was produced by trees grown on good soil. Crowding in forest stands reduced, in proportion to the density of the stand, the quantity of seed produced.

A direct comparison of age classes of trees grown under similar conditions with an average of these age classes from different localities brings out a general tendency for the seed to decrease in vitality as the age of the parent increases. This tendency is shown in Table 1.

The loss in vitality of the seed is reflected in the vigor of the seedlings, as shown by the decreased growth in height. Habits in length of growth periods are apparently not affected. The fluctuations are normal and do not follow in any consistent order.

The more vigorously growing trees of the lower slopes and valleys transmit to the seed they produce the tendency to vigorous growth. Table 2 shows that the seed gathered from the lower regions produced a higher germination percentage and larger seedlings than did that which was gathered at higher elevations.

TABLE 1. *Influence on the vitality of seed of the age of the parent tree*

No. of trees as basis	Age of parent tree in years	Germination of seed in percent	Growth of 1-year-old seedlings in inches	Percentage of buds that were mature at end of first growing season
18	14–30	48.2	1.6	60.9
22	30–75	46.0	1.6	57.5
19	75–200	45.6	1.6	61.1
8	200–300	42.7	1.5	50.7
6	300–400	38.8	1.4	58.5

Note: Data are based on six annual germination tests and on the growth of 1-year-old seedlings from each test. Three hundred seeds of each parent tree were used in each test.

Seedlings from seed of trees grown at the higher elevations would be expected to produce a greater percentage of mature buds, thereby showing their adaptation to a shorter growing season. The variation, however, is normal and does not show any consistent tendency either in favor of the lower-grown seed or that from higher altitudes.

TABLE 2. *Influence on its progeny of the elevation at which the parent tree grew*

No. of trees as basis	Elevation in feet at which tree grew	Germination of seed in percent	Growth of 1-year-old seedlings in inches	Percentage of buds that were mature at end of first growing season
9	500	53.8	1.6	70.2
4	2,600	44.1	1.6	78.0
8	3,000	39.0	1.5	73.0
1	3,800	26.4	1.3	67.0

Note: Data are based on six annual germination tests and on the growth of 1-year-old seedlings from each test. Three hundred seeds of each parent tree were used in each test.

Latitude would be expected to produce the same results as altitude. This may be true when wide limits are considered; but, within the range covered by this investigation, there is no marked influence on seed vitality or on growth of seedlings due to latitude. The extreme range covered by the parent trees represented in Table 3 is 246 miles north and south. Certain trees were taken in an intermediate location, 66 miles north of the southern limit. The region concerned lies in western Oregon and Washington, between latitude 44.75° and 48.25° N.

Mature "conky" (diseased) trees 200 to 450 years old produced a smaller percentage of viable seed than did healthy trees grown on similar soil. The growth of seedlings showed no weakness due to diseased parent trees. Seedlings were equally vigorous from both healthy and diseased parent trees, and in some instances the seedlings from the seed of the dis-

TABLE 3. *Fixation of characters due to regional environment*

No. of trees as basis	Region from which seed was gathered	Germination of seed in percent	Growth of 1-year-old seedlings in inches	Percentage of buds that were mature at end of first growing season
8	Gates, Ore., Lat. 44.75°	48.5	1.7	50.1
9	Carson, Wash., 66 miles north of Gates, Ore.	47.6	1.7	75.0
11	Darrington, Wash., 246 miles north of Gates, Ore.	51.7	1.5	68.0

Note: Data are based on six annual germination tests and on the growth of 1-year-old seedlings from each test. Three hundred seeds of each parent tree were used in each test.

eased trees were better than those grown from the seed of healthy trees. Table 4 represents a comparison of the seedling growth and the seed germination of healthy and diseased trees.

TABLE 4. *Influence on its progeny of the health of the parent tree*

No. of trees as basis	Health of parent tree	Germination of seed in percent	Growth of 1-year-old seedlings in inches	Percentage of buds that were mature at end of first growing season
11	Healthy	47.4	1.4	56.2
7	"Conkey" (Infected with fungi)	34.7	1.5	58.9

Note: Data are based on six annual germination tests and on the growth of 1-year-old seedlings from each test. Three hundred seeds of each parent tree were used in each test.

It has been shown before that the diseased trees produce less good seed than healthy trees do, and these results show that the vitality of the seed is also impaired. This study also provides conclusive evidence that the environmental conditions af the parent tree are reflected in its progeny in direct proportion to the extremes of the habitat factors of the parent tree. The range of conditions covered by the data presented is sufficient to supply the needs for silvicultural practice in this region, although the extremes are not included in all factors.

The results brought out are applicable in the methods of cutting the forest of this region and in reforestation. The outstanding conclusion is that the variations in vitality of seed and vigor of seedlings, caused by the environmental conditions of the parent tree, are not sufficiently pronounced to justify radical methods of management which may favor one or another of the factors. In so far as seed production, vitality of seed, and vigor of seedlings are concerned, there need be no selection of seed trees based on age, health, or soil in which they are growing, which will in any way interfere with the best economic utilization of the stand. When selection cutting is done thrifty well-formed trees will be left for future growth, and these will also become the most desirable seed trees.

The variations in seed production, vitality of seed, and growth of seedlings due to inheritance should not be overlooked in gathering seed for the purpose of growing nursery stock. So far as conditions permit, the best possible seed should be gathered.

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